Integrated Modeling

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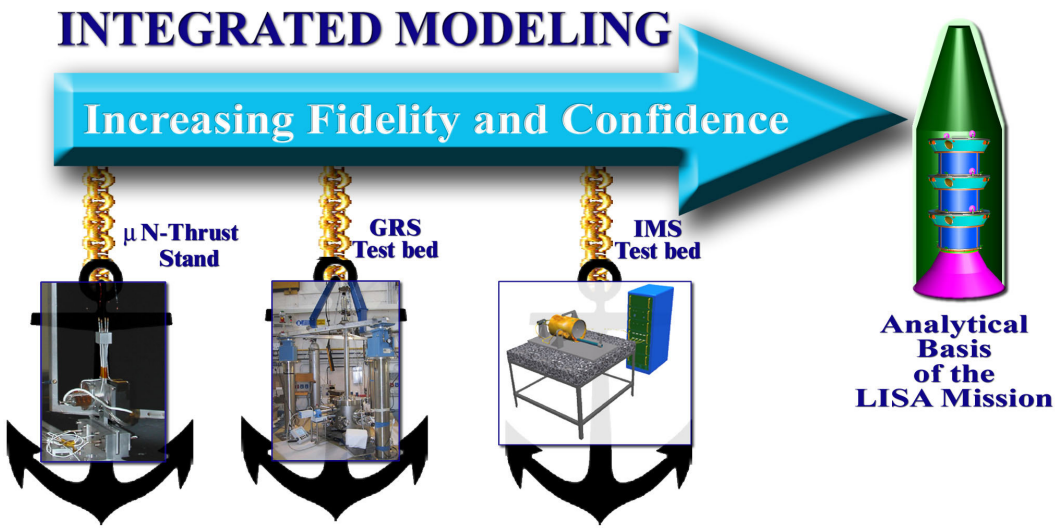
Integrated Modeling

Beyond Einstein: From the Big Bang to Black Holes



- LISA has intricate interactions between subsystems that require an integrated approach to modeling and testing.
- Multidisciplinary modeling and analysis seamlessly interwoven into the systems engineering process.
- Models “anchored” by testbeds and flight demo.
- Distributed team - Contributions from NASA, ESA, Science Team, Industry, and Universities.
- Government lead effort. It is expected that SE&I contractor will heavily support.

Plan for Developing Models

- Models initially developed by Project Integrated Modeling Team
- Final subsystem models are built and delivered by subsystem suppliers and SE&I contractor
- Core modeling team receives models, performs initial checks, and integrates into modeling environment
- Integrated Modeling Team works closely with both System Engineering and Technology Development

Integrated Modeling Phases

- Phase 1 (Formulation):
  - Establish baseline
  - Verify/derive system requirements
  - Risk assessment
  - Engineering trades
  - Modest integration
  - Feeds MCR
- Phase 2 (Formulation):
  - Engineering trades
  - Increased model integration
  - Feeds SRR
- Phase 3 (Formulation):
  - Full integration
  - Fully mature error trees and science data simulator
  - “Subtle” engineering trade studies
  - Publish Analytical Basis of the LISA Mission
  - Feeds PDR
- Phase 4 (Implementation):
  - Support I&T
  - Support science data simulator
  - Hardware in-the-loop tests
  - Support Flight Software
  - Support Operations
- Phase 5 (Post-Launch):
  - Support Operations
  - Support science data analysis

LISA Integrated Modeling Environment (LIME)

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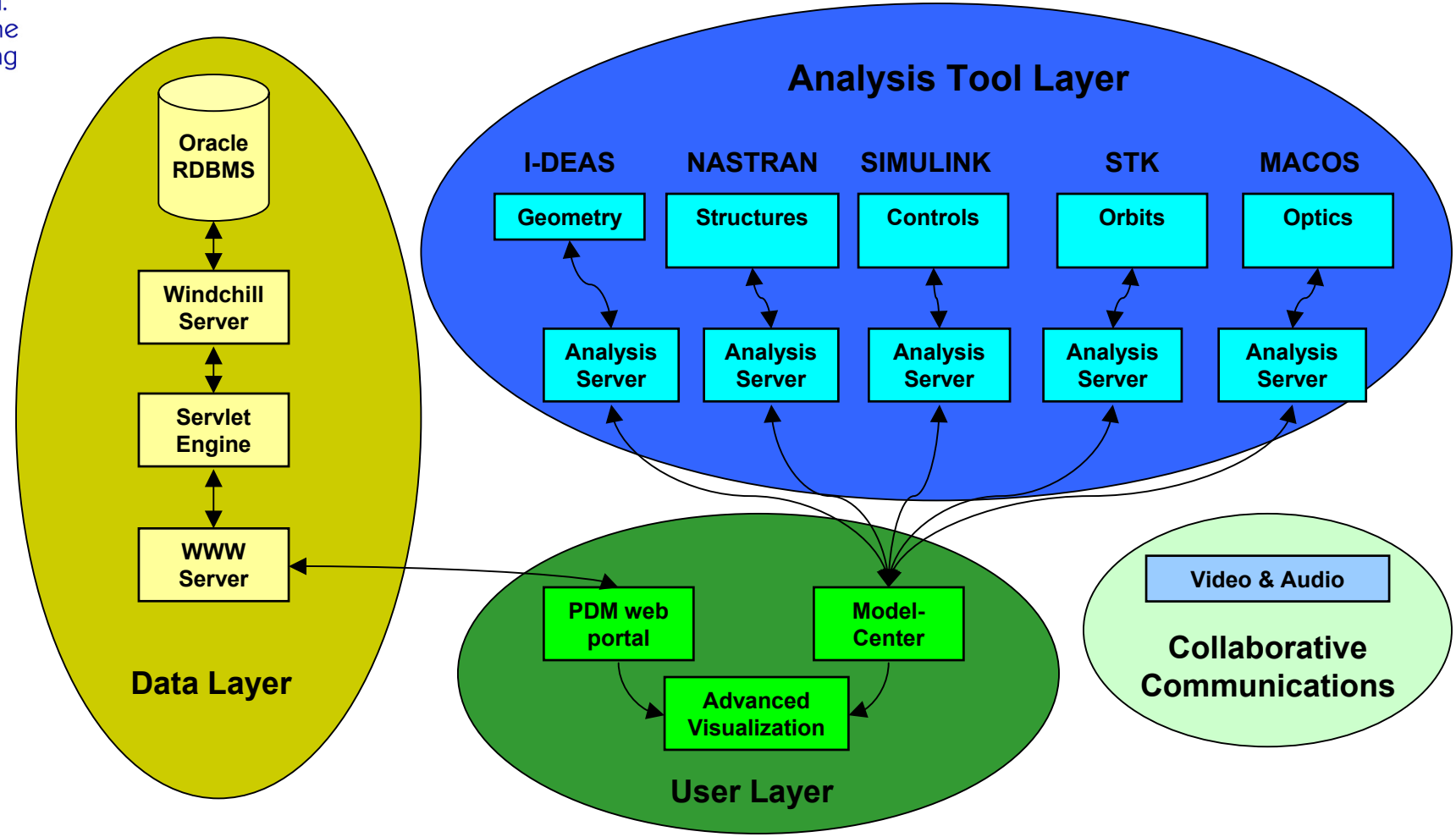

Partner & Leverage

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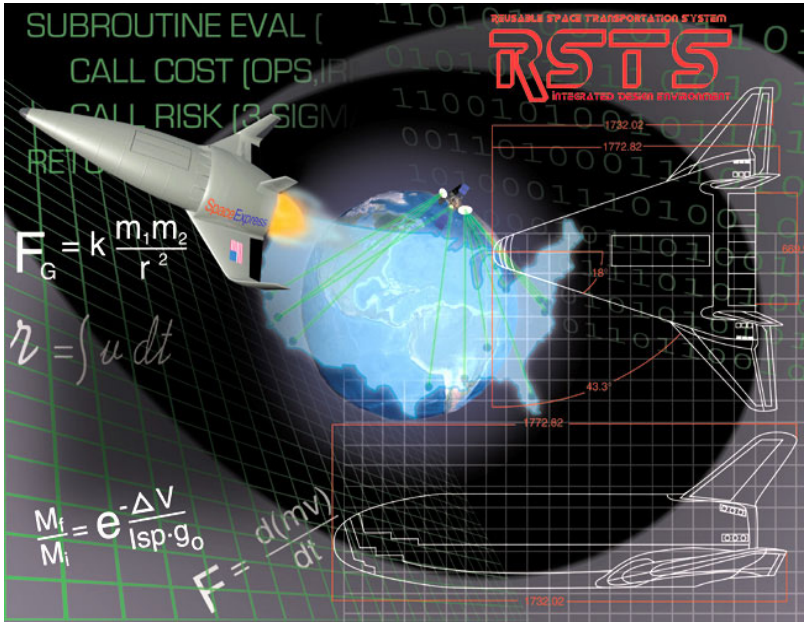
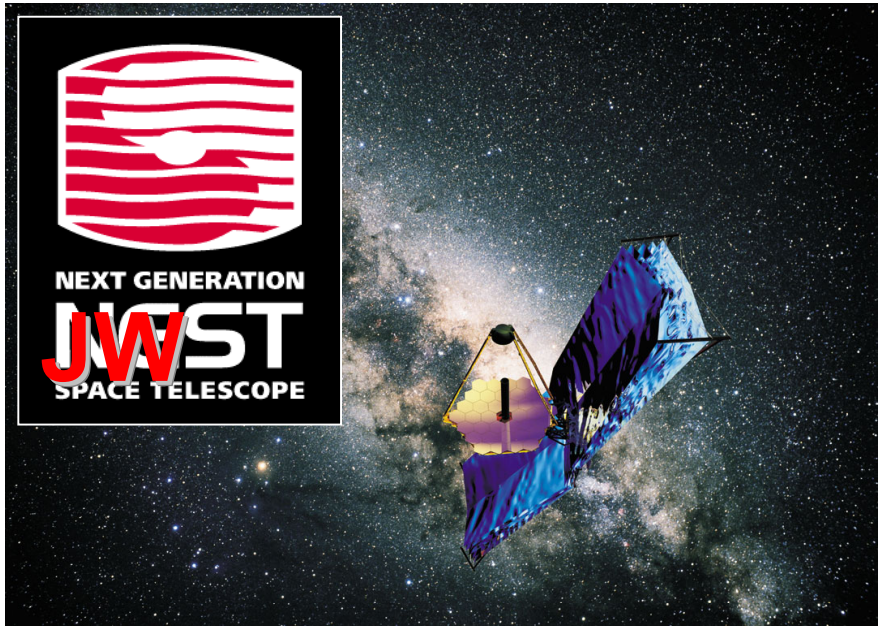
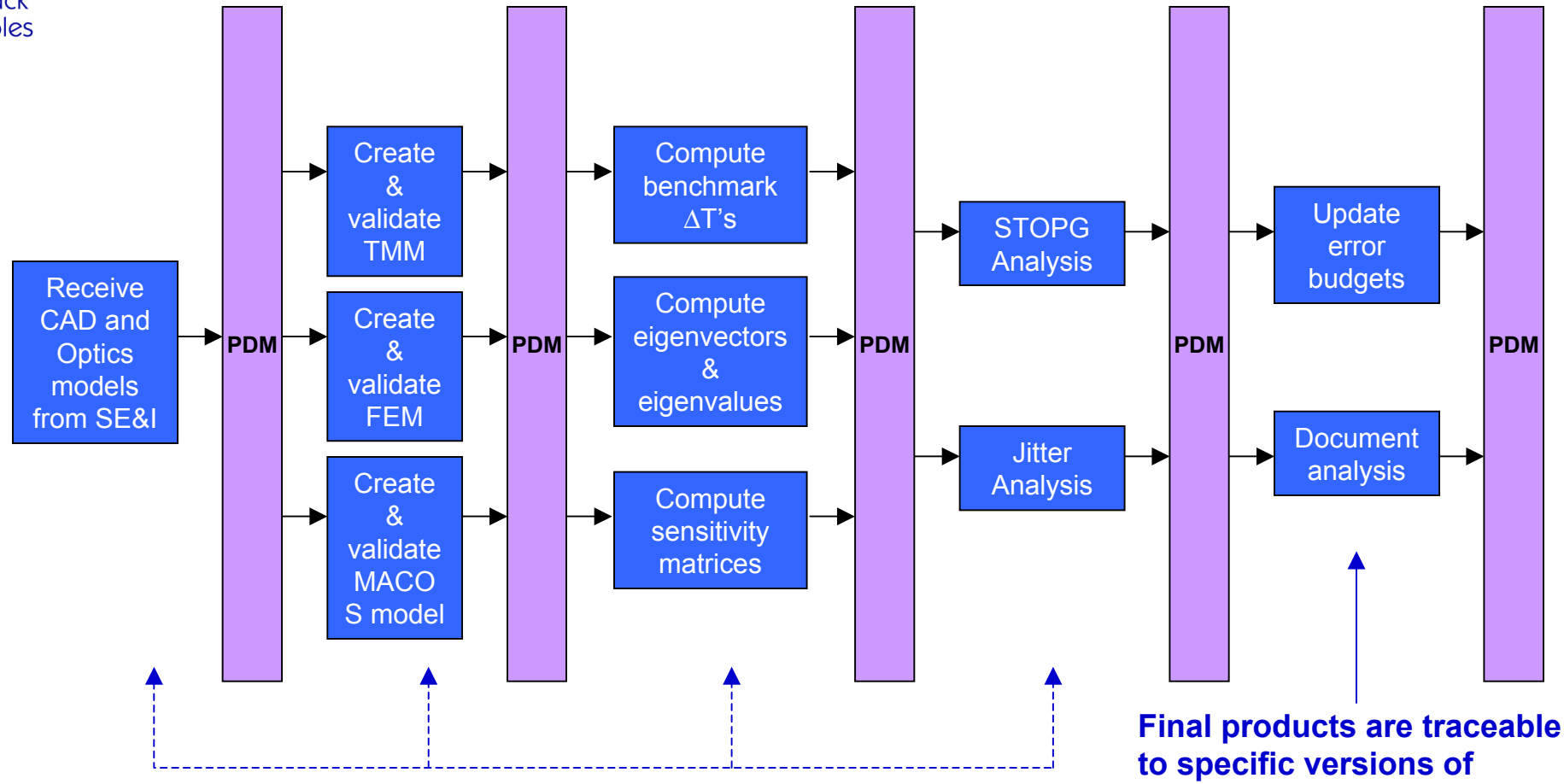




Modeling Task Execution Flow

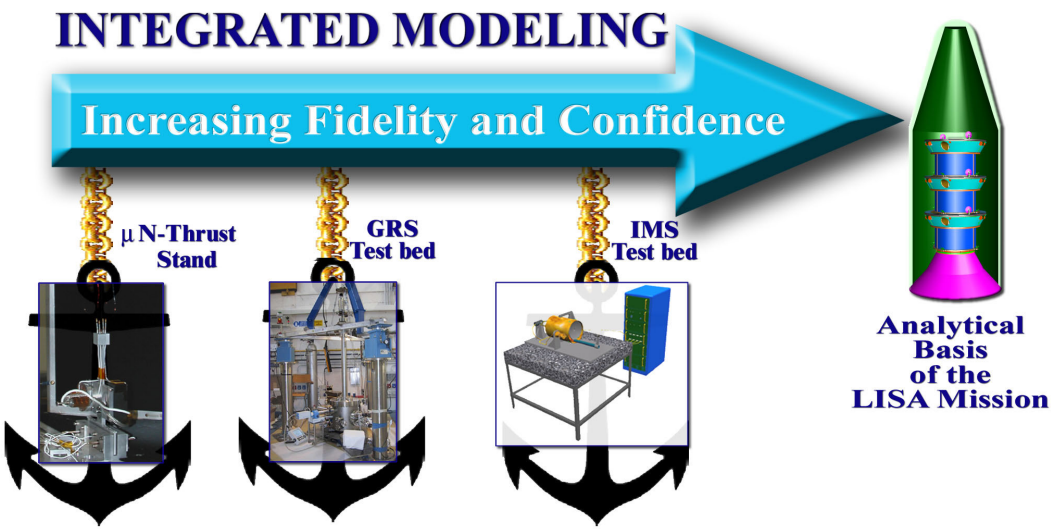
- Using LIME, a typical task might execute something like this…



Model Verification

- Modeling tools and techniques verified using benchmark problems
- Models built incrementally with verification procedures at each stage of development
- Verify the model synthesis (was the model assembled correctly)
  - Verification with simple benchmark tests for each discipline (e.g. FEM validity checks http://analyst.gsfc.nasa.gov/FEMCI/validitychecks/)
  - Benchmark tests for integrated modeling output
  - Comparison to existing model/results (e.g. contractor delivered data)
- Verify the model predictability:
  - Verification by similarity or re-use
  - Verification by cross-checking and review
  - Verification by test

Verification by Test



- Targeted studies
  - UW small force torsion pendulum
  - Kelvin Probe
  - Phase meter noise investigations
- Component level
  - μN-thrust stand
  - GRS test bed
  - Laser stabilization
- Subsystem level
  - IMS tester
  - DRS Simulator
  - SMART-2

End-To-End Modeling

- Integrated System Model:
  - Completed system models:
    - Numerous (non-integrated) analyses and error budgets show sensitivity to all significant noise sources
    - 19 DOF (1 S/C & 2 PM) control simulation
    - First generation science data simulator
    - Time Delay Interferometry simulation
  - System models currently under development:
    - 57 DOF (3 S/C & 6 PM) control simulation
    - Several second generation science data simulators under development
    - Integrated error trees
    - STOPG analysis
- Completed Discipline Models for baseline design:
  - Solid Geometry Model
  - Thermal model
  - Finite element model
  - Self-gravity
  - Telescope Sensitivity Analysis
  - Quad-precision ray-trace of telescopes & 5 million km path
  - Orbit optimizations